16:34:51 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 03/14/97

Active

Project #: C-36-X64 Cost share #: Rev #: 6
Center # : 10/24-6-R8687-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: DABT63-95-C-0125 Mod #: P00004 Document : CONT
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA: NA
Main project #: PE #: NA

Project unit: COMPUTING Unit code: 02.010.300
Project director(s):
SCHWAN K COMPUTING (404)894-2589

Sponsor/division names: ARMY / FT HUACHUCA, AZ
Sponsor/division codes: 102 / 014

Award period: 950915 to 960914 (performance) 960929 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	784,145.00
Funded	0.00	556,361.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: Y

Title: OBJECT TECHNOLOGY FOR HIGH PERFORMANCE SYSTEMS

PROJECT ADMINISTRATION DATA

OCA contact: William F. Brown 894-4820

Sponsor technical contact	Sponsor issuing office
MALVIN J. CHERNOW	PEGGY GENTEMAN
(520)538-0419	(520)538-0412
DIRECTORATE OF CONTRACTING	DIRECTORATE OF CONTRACTING
ATTN: ATZS-DKO-I (M. J. CHERNOW)	ATTN: ATZS-DKO-I
P.O. BOX 12748	POST OFFICE BOX 12748
FORT HUACHUCA, AZ 85670-2748	FORT HUACHUCA, AZ 85670-2748

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): Y
Defense priority rating : NA GOVT supplemental sheet
Equipment title vests with: Sponsor X GIT

Administrative comments -
MOD. P00004 TERMINATES CONTRACT (1/31/97) AND REQUESTS A NO-COST SETTLEMENT PROPOSAL ASAP. NO FURTHER CHARGES ARE ALLOWED.

4
7

PROJECT CLOSEOUT - NOTICE

5/13/02

Closeout Notice Date 07-OCT-1997

Project Number C-36-X64 Doch Id 46142

Center Number 10/24-6-R8687-0A0

Project Director SCHWANS, KARSTEN

Project Unit COMPUTING

Sponsor ARMY/FT HUACHUCA, AZ

Division Id 3236

Contract Number DABT63-95-C-0125 Contract Entity GTRC

Prime Contract Number

Title OBJECT TECHNOLOGY FOR HIGH PERFORMANCE SYSTEMS

Effective Completion Date 14-SEP-1996 (Performance) 29-SEP-1996 (Reports)

Closeout Action:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory and Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	Y	
Other	N	

Comments

Distribution Required:	
Project Director/Principal Investigator	Y
Research Administrative Network	Y
Accounting	Y
Research Security Department	N
Reports Coordinator	Y
Research Property Team	Y
Supply Services Department	Y
Georgia Tech Research Corporation	Y
Project File	Y

NOTE: Final Patent Questionnaire sent to PDPI

C-36- X64
#6

Man-Hour Report/A003
C36-X64/Army
4/1/96 - 6/30/96
Schwan/Ahamad

	April	May	June
Rosu, M.	37.50%	37.50%	37.50%
Bhola, S.	37.50%	37.50%	37.50%
Kordale, R.	50.00%	50.00%	50.00%
Silva, D.	50.00%	50.00%	50.00%

PROJECT EXPENDITURE & BUDGET REPORT

PRINCIPAL INVESTIGATOR K SCHWAN CENTER NO. 246R86870A0 ACCOUNT NO. C-36-X64

TRANSACTIONS FOR JUNE 1996 DEPARTMENT COLL COMP

DATE	DESCRIPTION	DOCUMENT	ID/REFERENCE	CODE	BUDGETS	ENCUMBRANCES	EXPENDITURES
PERSONAL SERVICES							
06/30/96	BHOLA, SUMEER			51144			1,061.00
06/30/96	EISENHAUER, GREG STE			51110			4,166.66
06/30/96	KORDALE, RAMMOHAN			51144			1,269.33
06/30/96	ROSU, MARCEL C.			51144			1,061.00
06/30/96	SILVA, DILMA			51144			1,269.33
06/28/96	MONTHLY PAYROLL		06-P070	C 51110		-4,166.66	
06/28/96	MONTHLY PAYROLL		06-P070	C 51144		-4,660.66	
	TOTAL					-8,827.32	8,827.32
FRINGE BENEFITS							
06/30/96	JUN 96 SPON BENE		06-P086	C 52022			17.77
06/30/96	JUN 96 SPON BENE		06-P086	C 52024			1,033.33
06/20/96	SPON BENEFITS ENCUMB		06-P044	C 52024		-1,033.33	
	TOTAL					-1,033.33	1,051.10
MATERIALS AND SUPPLIES							
06/10/96	AHAMAD,MUSTAQUE	360616411	00406089	M 72710			395.00
06/17/96	COC LAB USAG		06-264	C 76020			4,655.32
06/14/96	FEDERAL EXPRESS CORP	360620084	00408014	M 72720			15.25
06/03/96	MAC WAREHOUSE	360616407	00403572	M 71410			381.00
06/04/96	MAC WAREHOUSE	360616409	00404032	M 71410			381.00
06/04/96	MAC WAREHOUSE	360616408	00404032	M 71410			381.00
06/11/96	ROSU,MARCEL C	360616410	00406684	M 72710			100.00
06/03/96	SCHWAN,KARSTEN	360616406	00403767	M 72710			240.00
06/28/96	TO CORRECT CHECK #40	360620084	06-0880	C 72720			-15.25
06/08/96	AHAMAD,MUSTAQUE	360616411		H 72710		395.00	
06/10/96	AHAMAD,MUSTAQUE	360616411	00406089	M 72710		-395.00	
06/04/96	MAC WAREHOUSE	360616409	00404032	M 71410		-381.00	
06/04/96	MAC WAREHOUSE	360616409		I 71410		3.00	
06/11/96	ROSU,MARCEL C	360616410	00406684	M 72710		-100.00	
06/03/96	SCHWAN,KARSTEN	360616406	00403767	M 72710		-240.00	
	TOTAL					-718.00	6,533.32
TRAVEL							

PROJECT EXPENDITURE & BUDGET REPORT

PRINCIPAL INVESTIGATOR K SCHWAN CENTER NO. 246R86870A0 ACCOUNT NO. C-36-X64

TRANSACTIONS FOR JUNE 1996 DEPARTMENT COLL COMP

DATE	DESCRIPTION	DOCUMENT	ID/REFERENCE	CODE	BUDGETS	ENCUMBRANCES	EXPENDITURES
TRAVEL							
06/10/96	AHAMAD,MUSTAQUE	360616411	00406089	M 64005			555.00
06/03/96	SCHWAN,KARSTEN	360616406	00403767	M 64000			253.29
06/10/96	AHAMAD,MUSTAQUE	360616411	00406089	M 64005		-555.00	
06/03/96	SCHWAN,KARSTEN	360616406	00403767	M 64000		-253.29	
	TOTAL					-808.29	808.29
INDIRECT CHARGES							
	TOTAL RATE OF 46.0% BASE OF 4					-5,237.99	7,921.21
MONTHLY TOTAL						-16,624.93	25,141.24

INDIRECT COMPUTED ON TOTAL DIRECT CHARGES MINUS EQUIPMENT, SUBCONTRACTS OVER AUTHORIZED BASE, AND STUDENT AID

PRINCIPAL INVESTIGATOR	K SCHWAN	CENTER NO.	246R86870A0	ACCOUNT NO.	C-36-X64
STATUS AT END OF	JUNE 1996			DEPARTMENT	COLL COMP
SPONSOR	U S DEPT OF DEFENSE				
AWARD NUMBER	DABT63-95-C-0125	RF CENTER NO.	00641848000	RESTRICTED FUND	RF-43824
EFFECTIVE DATE	09-15-95	BILLING GROUP	GTRC	EXPIRATION DATE	09-14-96

	MONTH	FISCAL YEAR	TOTAL CONTRACT
PERSONAL SERVICES			
BUDGET			186,674.00
EXPENDED	8,827.32	59,546.07	59,546.07
ENCUMBERED	-8,827.32	.00	.00
FREE BALANCE			127,127.93
FRINGE BENEFITS			
BUDGET			29,141.00
EXPENDED	1,051.10	4,265.22	4,265.22
ENCUMBERED	-1,033.33	.00	.00
FREE BALANCE			24,875.78
MATERIALS AND SUPPLIES			
BUDGET			18,173.00
EXPENDED	6,533.32	8,567.26	8,567.26
ENCUMBERED	-718.00	.00	.00
FREE BALANCE			9,605.74
TRAVEL			
BUDGET			11,360.00
EXPENDED	808.29	2,921.15	2,921.15
ENCUMBERED	-808.29	979.71	979.71
FREE BALANCE			7,459.14
SUBCONTRACTS NON-MTDC			
BUDGET			25,000.00
EXPENDED	.00	.00	.00
ENCUMBERED	.00	.00	.00
FREE BALANCE			25,000.00

PRINCIPAL INVESTIGATOR	K SCHWAN	CENTER NO.	246R86870A0	ACCOUNT NO.	C-36-X64
STATUS AT END OF	JUNE 1996			DEPARTMENT	COLL COMP
SPONSOR	U S DEPT OF DEFENSE				
AWARD NUMBER	DABT63-95-C-0125	RF CENTER NO.	00641848000	RESTRICTED FUND	RF-43824
EFFECTIVE DATE	09-15-95	BILLING GROUP	GTRC	EXPIRATION DATE	09-14-96

	MONTH	FISCAL YEAR	TOTAL CONTRACT	
SUBCONTRACTS MTDC				
BUDGET			161,690.00	
EXPENDED	.00	.00	.00	
ENCUMBERED	.00	.00	.00	
FREE BALANCE			161,690.00	
TOTAL DIRECT CHARGES				
BUDGET			432,038.00	
EXPENDED	17,220.03	75,299.70	75,299.70	
ENCUMBERED	-11,386.94	979.71	979.71	
FREE BALANCE			355,758.59	
INDIRECT CHARGES				
BUDGET			124,323.00	
EXPENDED	7,921.21	34,637.85	34,637.85	RATE OF 46.0 BASE OF 4
ENCUMBERED	-5,237.99	450.68	450.68	
FREE BALANCE			89,234.47	
TOTAL				
BUDGET			556,361.00	
EXPENDED	25,141.24	109,937.55	109,937.55	
ENCUMBERED	-16,624.93	1,430.39	1,430.39	
FREE BALANCE			444,993.06	

C- 36- X64
#5

R&D Status report
for C36-X64 due 7/15/96.
submitted electronically
to ARPA on 7/15/96

<ITO_PROJECT_INFORMATION>

<PROJECT_SUMMARY>

<AO_NUMBER>
D023
</AO_NUMBER>

<CONTRACTOR_OR_ORGANIZATION_NAME>
Georgia Institute of Technology
</CONTRACTOR_OR_ORGANIZATION_NAME>

<SUBCONTRACTOR_LIST>

<SUBCONTRACTOR>

<SUB_NAME>
IBM TJ Watson Research Laboratory
</SUB_NAME>
<DOLLAR_AMOUNT>
493,924
</DOLLAR_AMOUNT>

</SUBCONTRACTOR>

</SUBCONTRACTOR_LIST>

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</CO-PRINCIPAL_INVESTIGATOR>

</PRINCIPAL_INVESTIGATOR_LIST>

<TITLE_OF_EFFORT>

Configurable Objects for High Performance Systems

</TITLE_OF_EFFORT>

<RELATED_INFORMATION>
http://www.cc.gatech.edu/systems/projects/COBS
</RELATED_INFORMATION>

<OBJECTIVE>
The COBS project is developing a uniform programming model for high performance, heterogeneous machines. The intent of our work is to have broad impact by leveraging commercial object technologies, while simultaneously attaining high performance by gaining and using novel research insights on efficient object representations.
</OBJECTIVE>

<APPROACH>
The object model has been shown to be useful in developing very large scale applications, however existing commercial object implementations do not offer the performance necessary for use in demanding environments. The COBS project is addressing this problem by developing a configurable object support layer that allows object implementations to adapt to the both the demands of the application and the capabilities of the hardware. Particular attention is being paid to the need to support efficient distributed and fragmented object abstractions which can adapt to different network transport protocols with vastly different bandwidth, latency and availability characteristics.
</APPROACH>

<RECENT_96_ACCOMPLISHMENT>
Development of the configurable Object Transport Layer (the core of the Object Request Broker, in CORBA terms).
</RECENT_96_ACCOMPLISHMENT>

<RECENT_96_ACCOMPLISHMENT>
Development of configurable and high performance communication substrates for use by OTL.
</RECENT_96_ACCOMPLISHMENT>

<RECENT_96_ACCOMPLISHMENT>
Development of mutual consistency abstraction for objects and their realization in a Fresco-based system.
</RECENT_96_ACCOMPLISHMENT>

<RECENT_96_ACCOMPLISHMENT>
IDL-based object invocation interface and notion of configuration objects and attributes realized in this context.
</RECENT_96_ACCOMPLISHMENT>

<RECENT_96_ACCOMPLISHMENT>
Design and partial implementation of CORBA COS event channels with IBM.
</RECENT_96_ACCOMPLISHMENT>

<FY1997_PLAN>
Integration of configurable communications into the Object Transport Layer.
</FY1997_PLAN>

<FY1997_PLAN>
Experimental evaluation with high performance applications.
</FY1997_PLAN>

<FY1997_PLAN>
Experimental evaluation with interactive applications, including remote high quality visualizations.
</FY1997_PLAN>

<FY1997_PLAN>
Interaction with additional companies for technology transfer, including small business units like SYSTRAN Corp.
</FY1997_PLAN>

<TECHNOLOGY_TRANSITION>
Joint work with IBM on a CORBA object services event channel implementation known as the Event Reaction Architecture may be incorporated into IBM's commercial distributed object system. IBM's efforts may lead to its incorporation into emerging industry-wide standards for inter-ORB interaction.
</TECHNOLOGY_TRANSITION>

</PROJECT_SUMMARY>

<ADMINISTRATIVE_AND_FINANCIAL_DATA>

<DATE_PREPARED>
12 JUL 1996
</DATE_PREPARED>

<AWARD_NUMBER>
DABT63-95-C-0125
</AWARD_NUMBER>

<AWARD_AGENT>
ARPA/CSTO
</AWARD_AGENT>

<AWARD_TITLE>
Object Technology for High Performance Systems
</AWARD_TITLE>

<ACTUAL_START_DATE>

15 SEP 1995
</ACTUAL_START_DATE>

<ACTUAL_START_DATE_COMMENT>
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<OFFICIAL_AWARD_END_DATE>
14 SEP 1998
</OFFICIAL_AWARD_END_DATE>

<CURRENT_AWARD_FUNDING_PROFILE_BY_YEAR>

FY95	Base	113,893
FY96	Base	391,412
FY97	Base	397,965
FY98	Base	289,304
TOTAL	Base	1,192,574

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<TOTAL_FUNDS_PROVIDED_TO_DATE>

Base 556,361.00

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<ACTUAL_FUNDS_EXPENDED_TO_DATE>

Base 337,376.27

</ACTUAL_FUNDS_EXPENDED_TO_DATE>

<DATE_CURRENT_FUNDING_EXPENDED>
20 JAN 1997
</DATE_CURRENT_FUNDING_EXPENDED>

<FUNDING_BY_FISCAL_QUARTER>

Base Effort	PLANNED	PROVIDED	DELTA
Funding for 7/96-9/96	98,414	98,414	0
Funding for 10/96-12/96	98,414	98,414	0
FY96 Base	196,828	196,828	0
Funding for 1/97 - 3/97	98,414	22,157	76,257
Funding for 4/97 - 6/97	98,414	0	98,414
Funding for 7/97 - 9/97	102,107	0	102,107
Funding for 10/97 - 11/97	102,107	0	102,107
FY97 Base	225,000	22,157	378,885

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<DATE_OF_FINANCIAL_DATA>
30 JUN 1996
</DATE_OF_FINANCIAL_DATA>

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</ADMINISTRATIVE_AND_FINANCIAL_DATA>

</ITO_PROJECT_INFORMATION>

C-36-X64
1, 2 (new)

Object Technology for High Performance Systems

(Project Status Report - Contract DABT63-95-C-0125)

Start Date: October 1, 1995

Karsten Schwan
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Chris Codella
Bodhi Mukherjee
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1 COBS: Configurable OBjectS for High Performance Systems

The COBS project is developing a uniform object-oriented programming infrastructure for high performance, heterogeneous machines. The intent of our work is to have broad impact by leveraging commercial object technologies while simultaneously attaining high performance by gaining and using novel research insights on efficient object representations and implementations. The performance improvements will be achieved through the use of highly configurable object and network interfaces. Through a single set of mechanisms and a uniform programming model, COBS will allow the construction and adaption of object systems that efficiently support a diverse selection of programming styles and allow them to interoperate cleanly across the range of target machines from distributed to shared memory platforms. The unique collaboration between Georgia Tech and IBM's TJ Watson Research Center will allow the exploratory implementations developed in academic research to be integrated with established and developing industry standards in commercial contexts.

2 Completed Work

In the initial three months of this project, we have focussed our efforts on finalizing the architecture and design of the COBS object system. Additional work has been directed towards completing the required infrastructure and developing COBS applications. The requirements of these applications will guide our further development.

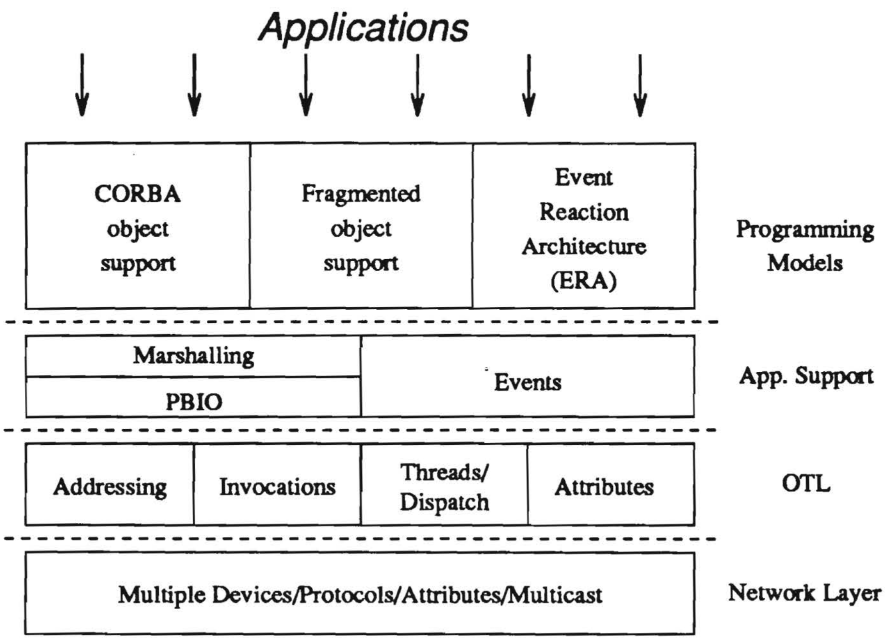

Figure 1: COBS System Architecture

2.1 COBS Architecture

The COBS system architecture is summarized in Figure 1. The Object Transport Layer (OTL) is a central component of the system architecture. It is designed to support the operation and inter-operation of a variety of programming models, including: traditional CORBA-style object systems, systems with more complex distributed or fragmented objects, and explicitly reactive object systems like the Event Reaction Architecture. A key feature of the design is the use of object and invocation *attribute lists.* Attributes are name-value pairs that control system characteristics and provide a uniform mechanism through which the behavior of all layers of the COBS architecture can be configured to achieve the required performance. Among the system characteristics which can be controlled by applications are:

- selecting between multiple object implementations
- creating passive, single-, or multi-threaded objects
- fragmenting or replicating object state
- using reliable, unreliable or multicast protocols for invocations
- specifying compressed or secure protocols for data exchange

Attributes are associated with every object operation and so can affect the behavior of any system component involved in performing that operation. Each system component processes the attributes that it understands and the remaining attributes are passed on. When object operations cross machine boundaries, the operation attributes are passed on as well so that the receiving systems behavior can be customized. The range of attributes is not limited or predefined. Because attributes can be examined as well as specified at the application level, they can be used by applications for customizing their own functional behavior as well as for configuring the underlying system.

The Object Transport Layer of COBS is built on top an instrumented version of the Georgia Tech Cthreads library. This library provides user-level threads support on a variety of uniprocessors and shared memory multiprocessors. The instrumentation support in Cthreads allows system and application performance information to be extracted for on-line or post-mortem performance analysis or tuning. This data extraction is done with minimal system perturbation and should prove invaluable in tuning applications and experimenting with new system configurations and protocols.

In order to insulate the system from machine differences and provide for efficient heterogeneous operation, a portable binary I/O package (PBIO) is being used in several situations. PBIO is a self-describing data meta-format capable of representing structured information and transmitting it between machines in a reader-makes-right protocol. COBS uses PBIO above the network layer for the transmission of attributes and other information required for its operation. Above the OTL, PBIO is used for packaging invocation parameters for transmission between machines.

2.2 Communications Infrastructure

Efficient exploitation of network resources in a dynamic heterogeneous environment requires a capable and configurable communications system. COBS will gain performance improvements in distributed environments by customizing communications to match the requirements of the application. This configuration can take many forms, such as the selective relaxation of such things as ordering and reliable delivery protocols or the use of compression protocols appropriate to the type of data transmitted (image, audio, video). In order to allow separate and concurrent development of the OTL and the communications infrastructure we have formalized the interfaces between these layers of COBS.

Based on this interface, several communication protocols will be utilized for COBS communications, including a real-time protocol offering guarantees for quality of service, a zero copy ATM protocol offering very high performance communications across homogeneous machines, and a configurable communication protocol permitting the on-line reconfiguration and adaptation of selected protocol processing. Conventional protocols will be used as well.

2.3 Distributed Shared Memory

Distributed shared memories (DSM) allow processes to share memory objects even when they execute in environments such as workstation cluster where shared memory is not provided by the the hardware. We have implemented Indigo, a user-level library which can be used to implement several types of distributed memory systems. We have already implemented a DSM that exploits weak consistency and synchronization information to provide high performance memory objects. Both Indigo and the DSM systems currently run on Sun and SGI workstation clusters as well as on the IBM SP-2 machine. We have developed several novel techniques to improve performance of memory objects. For example, we have developed a scheme for handling false sharing that incurs additional overhead only when false sharing is actually present.

3 Work in Progress

In the next quarter, we will concentrate on building the functionality of the OTL and porting several applications and systems to run on top of this object interface.

3.1 OTL and Infrastructure

To complete the full functionality of the OTL as described in the COBS architecture above requires extending the capabilities of some of the infrastructure on which COBS is based. In particular, at least the following extensions are known to be necessary:

PBIO In the COBS architecture, PBIO is used to handle inter-OTL communication and for application parameter passing. In the latter use, the OTL passes uninterpreted PBIO parameter blocks between machines which are unpacked by higher layers. This requires the extension of PBIO to support a memory-to-memory model of encoding data values.

Cthreads COBS uses the user-level threads in Cthreads as a vehicle for executing object invocations. Cthreads basic functionality is sufficient to support this role in most circumstances, but Cthreads is not currently not a preemptive threads package. In order to support fully asynchronous invocations, Cthreads must be extended with preemptive schedulers and signal handling capability.

3.2 DSM

Indigo, the system we have used for implementing DSM, currently is layered on top of PVM. To support efficient memory objects in COBS, we are moving Indigo on top of the OTL in COBS. This implementation of Indigo will exploit object technology. In addition, we are building an adaptive scheme for handling false sharing. Based on access patterns of shared memory objects, this scheme shifts the handling of false sharing related functions to user or server nodes to reduce communication and processing overheads. We expect both Indigo and the DSM system to be operational in COBS in the next three months.

3.3 Caching of CORBA Compliant Objects

CORBA compliant objects allow applications to be built in a heterogeneous environment. However, the performance of CORBA compliant object implementations has not been satisfactory. We have added object caching at client nodes to the Fresco toolkit which provides significantly better performance when there is reasonable access locality. This system has demonstrated the performance improvements that are possible with object replication and caching with flexible notions of consistency among copies. To allow COBS to benefit from these performance enhancing techniques, we are porting Fresco from Sun RPC to the COBS OTL layer. Apart from the implementation effort, we are addressing the issues of attributes and how they can be used with CORBA objects.

3.4 High Performance Computing and Collaborative Applications

Several HPC applications developed at Georgia Tech will be ported and tuned to run on COBS in order to evaluate the sufficiency of the facilities provided. Two of the most complex applications are a molecular dynamics simulation and a global atmospheric climate model. Both are parallel applications written in C and have been developed in collaboration with scientists in the respective fields. The applications will be adapted to use the COBS OTL for their communication needs. We expect that the demands of these HPC applications will help us to understand and meet the needs of object-based high performance computing.

Other efforts at Georgia Tech are developing tools and systems to allow scientists working on HPC applications such as those above to collaborate online without the need to be physically colocated. In particular, multiple scientists should be able to interact with and control an running HPC application remotely as well as interact with each other through shared and complimentary displays. This sort of interactive collaboration requires high-speed and low latency multimedia communication capability as well as sophisticated support for data sharing and interaction in a heterogeneous environment. These are the design goals for COBS we will be examining the role that COBS can play in the support of these distributed laboratories.

Man-Hour Report/A003
C36-X64/Army
9/15/95 - 12/31/95
Schwan/Ahamad

	Sept	Oct	Nov	Dec
Kohli, P.		50%	50%	50%
Eisenhauer, G.		50%	50%	50%

PROJECT EXPENDITURE & BUDGET REPORT

PRINCIPAL INVESTIGATOR K SCHWAN CENTER NO. 246R86870A0 ACCOUNT NO. C-36-X64

TRANSACTIONS FOR DECEMBER 1995 DEPARTMENT COLL COMP

DATE	DESCRIPTION	DOCUMENT ID/REFERENCE		CODE	BUDGETS	ENCUMBRANCES	EXPENDITURES
PERSONAL SERVICES							
12/31/95	EISENHAUER, GREG STE			51144			1,269.33
12/31/95	KOHLI, PRINCE			51144			1,269.33
12/29/95	MONTHLY PAYROLL		12-P062	C 51144		-2,538.66	
	TOTAL					-2,538.66	2,538.66
MATERIALS AND SUPPLIES							
12/18/95	SCHWAN,KARSTEN	360616400	00354994	M 72710			687.50
12/18/95	SCHWAN,KARSTEN	360616400	00354994	M 72710		-687.50	
12/18/95	SCHWAN,KARSTEN	360616400	18854536	I 72710		.50	
	TOTAL					-687.00	687.50
TRAVEL							
12/18/95	SCHWAN,KARSTEN	360616400	00354994	M 64000			93.00
12/18/95	SCHWAN,KARSTEN	360616400	00354994	M 64000		-93.00	
	TOTAL					-93.00	93.00
INDIRECT CHARGES							
	TOTAL RATE OF 46.0%	BASE OF 4				-1,526.58	1,526.81
MONTHLY	TOTAL					-4,845.24	4,845.97

GEORGIA INSTITUTE OF TECHNOLOGY

PRINCIPAL INVESTIGATOR	K SCHWAN	CENTER NO. 246R86870A0	ACCOUNT NO. C-36-X64
STATUS AT END OF	DECEMBER 1995		DEPARTMENT COLL COMP
SPONSOR	U S DEPT OF DEFENSE		
AWARD NUMBER	DABT63-95-C-0125	RF CENTER NO. 00641848000	RESTRICTED FUND RF-43824
EFFECTIVE DATE	09-15-95	BILLING GROUP GTRC	EXPIRATION DATE 09-14-96

	MONTH	FISCAL YEAR	TOTAL CONTRACT
PERSONAL SERVICES			
BUDGET			50,792.00
EXPENDED	2,538.66	7,615.98	7,615.98
ENCUMBERED	-2,538.66	.00	.00
FREE BALANCE			43,176.02
FRINGE BENEFITS			
BUDGET			7,716.00
EXPENDED	.00	.00	.00
ENCUMBERED	.00	.00	.00
FREE BALANCE			7,716.00
MATERIALS AND SUPPLIES			
BUDGET			5,110.00
EXPENDED	687.50	687.50	687.50
ENCUMBERED	-687.00	.00	.00
FREE BALANCE			4,422.50
TRAVEL			
BUDGET			3,280.00
EXPENDED	93.00	93.00	93.00
ENCUMBERED	-93.00	471.00	471.00
FREE BALANCE			2,716.00
SUBCONTRACTS MTDC			
BUDGET			53,534.00
EXPENDED	.00	.00	.00
ENCUMBERED	.00	.00	.00
FREE BALANCE			53,534.00
TOTAL DIRECT CHARGES			
BUDGET			120,432.00
EXPENDED	3,319.16	8,396.48	8,396.48
ENCUMBERED	-3,318.66	471.00	471.00
FREE BALANCE			111,564.52

PRINCIPAL INVESTIGATOR	K SCHWAN	CENTER NO.	246R86870A0	ACCOUNT NO.	C-36-X64
STATUS AT END OF	DECEMBER 1995			DEPARTMENT	COLL COMP
SPONSOR	U S DEPT OF DEFENSE				
AWARD NUMBER	DABT63-95-C-0125	RF CENTER NO.	00641848000	RESTRICTED FUND	RF-43824
EFFECTIVE DATE	09-15-95	BILLING GROUP	GTRC	EXPIRATION DATE	09-14-96

	MONTH	FISCAL YEAR	TOTAL CONTRACT	
INDIRECT CHARGES				
BUDGET			42,273.00	
EXPENDED	1,526.81	3,862.37	3,862.37	RATE OF 46.0 BASE OF 4
ENCUMBERED	-1,526.58	216.67	216.67	
FREE BALANCE			38,193.96	
TOTAL				
BUDGET			162,705.00	
EXPENDED	4,845.97	12,258.85	12,258.85	
ENCUMBERED	-4,845.24	687.67	687.67	
FREE BALANCE			149,758.48	

C-36-X64
3&4

Object Technology for High Performance Systems

Project Status Report - April 1996

Contract DABT63-95-C-0125
Start Date: October 1, 1995

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1 COBS: Configurable OBjectS for High Performance Systems

The COBS project is developing a uniform object-oriented programming infrastructure for high performance, heterogeneous machines. The intent of our work is to have broad impact by leveraging commercial object technologies while simultaneously attaining high performance by gaining and using novel research insights on efficient object representations and implementations. The performance improvements will be achieved through the use of highly configurable object and network interfaces. Through a single set of mechanisms and a uniform programming model, COBS will allow the construction and adaption of object systems that efficiently support a diverse selection of programming styles and allow them to interoperate cleanly across the range of target machines from distributed to shared memory platforms. The unique collaboration between Georgia Tech and IBM's TJ Watson Research Center will allow the exploratory implementations developed in academic research to be integrated with established and developing industry standards in commercial contexts.

2 Project Management

In this quarter, Georgia Tech hosted a site visit by Mark Gersh. The IBM group participated via speaker phone in a discussion of project progress, contents and directions.

Karsten Schwan, Mustaque Ahamad and Greg Eisenhauer also attended an ARPA PI meeting in San Antonio, to help direct project contents towards ARPA goals.

3 Project Progress

In the last quarter, we have continued work on the individual components of the COBS system and are making progress towards convergence.

3.1 COBS Architecture

The Object Transport Layer (OTL) is a central component of the system architecture. It is designed to support the operation and inter-operation of a variety of programming models, including: traditional CORBA-style object systems, systems with more complex distributed or fragmented objects, and explicitly reactive object systems like the Event Reaction Architecture.

A preliminary version of OTL is working, based on our Datahub communications package and Ithreads user-level threads package. This version interprets a limited set of attributes and is capable of performing threaded or non-threaded remote object invocations and transporting uninterpreted parameter blocks.

We have also begun moving some applications onto the OTL. As this process proceeds we are refining the OTL and extending the set of attributes through which it can be configured.

3.2 Caching of CORBA Compliant Objects

CORBA compliant objects allow applications to be built in a heterogeneous environment. However, the performance of CORBA compliant object implementations has not been satisfactory. We have added object caching at client nodes to the Fresco toolkit which provides significantly better performance when there is reasonable access locality. This system has demonstrated the performance improvements that are possible with object replication and caching with flexible notions of consistency among copies.

Distributed objects which are used to build scalable services need to the replicated and cached at clients to avoid high latency and communication costs. Consistency needs to be maintained across the multiple copies that result from such replication and caching. We have developed scalable consistency algorithms where consistency overheads at a node only depend on the accesses actually made by the node. Furthermore, our algorithms provide multiple levels of consistency for a related group of objects. Such levels can be changed based on application needs and the availability of resources. These algorithms are described in a paper that will be published in the proceedings of the International Conference on Distributed Computing, May 1996. Currently we are exploring the implementation of these consistency algorithms by enhancing a CORBA compliant system by adding object caching to it. We are also investigating applications that will be based on this distributed object system which will be used in the evaluation of the consistency algorithms.

The initial prototype of the object caching system was layered on top of Fresco version 0.7. A more recent version of Fresco became publicly available recently. Most of our effort this quarter has been in the area of porting the object caching system on top of the latest release of Fresco. Simultaneously, efforts are on to port the object caching system on top of OTL. While Fresco provided an object veneer on top of synchronous remote procedure calls (RPC), OTL provides a much richer transport layer. Consequently, the design of our system needs to be changed to take advantage of the advanced features of OTL such as asynchronous object invocations and user level threads. Thus, the effort to port our system on top of OTL is geared towards coming up with the above mentioned design.

3.3 Communications Infrastructure

Efficient exploitation of network resources in a dynamic heterogeneous environment requires a capable and configurable communications system. COBS will gain performance improvements in distributed environments by customizing communications to match the requirements of the application. This configuration can take many forms, such as the selective relaxation of such things as ordering and reliable delivery protocols or the use of compression protocols appropriate to the type of data transmitted (image, audio, video). In order to allow separate and concurrent development of the OTL and the communications infrastructure we have formalized the interfaces between these layers of COBS.

Based on this interface, several communication protocols will be utilized for COBS communications, including a real-time protocol offering guarantees for quality of service, a zero copy ATM protocol offering very high performance communications across homogeneous machines, and a configurable communication protocol permitting the on-line reconfiguration and adaptation of selected protocol processing. Conventional protocols will be used as well.

In the last quarter we have ported the zero copy ATM protocol to a new version of the FORE ATM cards. We are currently extending the protocol to provide a more general infrastructure for communication-application synchronization.

3.4 Distributed Shared Memory and Memory Objects

Distributed shared memories (DSM) allow processes to share memory objects even when they execute in environments such as workstation cluster where shared memory is not provided by the the hardware. We have implemented Indigo, a user-level library which can be used to implement several types of distributed memory systems. We have already implemented a DSM that exploits weak consistency and synchronization information to provide high performance memory objects.

Processes executing in a workstation cluster environment can share memory by using *memory objects* which can be read and written at multiple nodes. Such memory objects were constructed on top of the Indigo system that has been implemented by us. We have redesigned Indigo to exploit faster ATM based communication support and have also addressed several other problems of the current design such as use of separate processes as daemons. The new system is currently being implemented and will be integrated with the OTL discussed previously.

We have also designed and implementation of a new algorithm to handle false sharing(FS) in object based DSM systems(with Prince Kohli). As object based DSM systems allow user-defined objects, FS is not the common case. We have developed an algorithm which eliminates the overhead of handling FS when it is not present while correctly handling the cases in which FS occurs.

3.5 Preemptive User-level Threads System

Early development of the OTL has been layers on Ithreads, but I threads does not allow preemptive scheduling or safe signal handling. To address these deficiencies and allow for more flexibility in the final object system, we are developing another threads package which will be both preemptive and more configurable than Ithreads. The package has been constructed by plugging together various modules like the scheduler, dispatcher, lock manager etc. The connections can be dynamically reconfigured at runtime to support low overhead monitoring of long running parallel applications. It has been implemented on SunOS 5.5. We are currently exploring it's usefulness in the context of a DSM system.

Man-Hour Report/A003
C36-X64/Army
1/1/96 - 3/31/96

Schwan/Ahamad

	Jan.	Feb.	Mar.
Kohli, P.	50%	50%	50%
Rosu, M.	37.50%	37.50%	37.50%
Bhola, S.			37.50%
Kordale, R.			50%
Silva, D.	50%	50%	50%

GEORGIA INSTITUTE OF TECHNOLOGY

PROJECT EXPENDITURE & BUDGET REPORT

PRINCIPAL INVESTIGATOR K SCHWAN CENTER NO. 246R86870A0 ACCOUNT NO. C-36-X64

TRANSACTIONS FOR MARCH 1996 DEPARTMENT COLL COMP

DATE	DESCRIPTION	DOCUMENT ID/REFERENCE		CODE	BUDGETS	ENCUMBRANCES	EXPENDITURES
PERSONAL SERVICES							
03/31/96	BHOLA, SUMEER			51144			1,061.00
03/31/96	EISENHAUER, GREG STE			51110			4,166.66
03/31/96	KOHLI, PRINCE			51144			1,269.33
03/31/96	KORDALE, RAMMOHAN			51144			1,269.33
03/31/96	ROSU, MARCEL C.			51144			1,061.00
03/31/96	SILVA, DILMA			51144			1,269.33
03/22/96	ENCUMBRANCE ADJSTMNT		03-P051	C 51144		14,606.97	
03/29/96	MONTHLY PAYROLL		03-P066	C 51110		-4,166.66	
03/29/96	MONTHLY PAYROLL		03-P066	C 51144		-5,929.99	
	TOTAL					4,510.32	10,096.65
FRINGE BENEFITS							
03/31/96	MAR 96 SPON BENE		03-P077	C 52024			1,033.33
03/11/96	SPON BENEFITS ENCUMB		03-P032	C 52022		-233.33	
03/11/96	SPON BENEFITS ENCUMB		03-P032	C 52024		4,133.33	
03/21/96	SPON BENEFITS ENCUMB		03-P048	C 52024		-1,033.33	
	TOTAL					2,866.67	1,033.33
MATERIALS AND SUPPLIES							
03/11/96	EISENHAUER,GREG	360616404	00377547	M 72710			210.00
03/04/96	SCHWAN,KARSTEN	360616403	00375784	M 72710			210.00
03/11/96	EISENHAUER,GREG	360616404	00377547	M 72710		-210.00	
03/11/96	EISENHAUER,GREG	360616404		H 72710		210.00	
03/02/96	SCHWAN,KARSTEN	360616403		H 72710		210.00	
03/04/96	SCHWAN,KARSTEN	360616403	00375784	M 72710		-210.00	
	TOTAL					.00	420.00
TRAVEL							
03/11/96	EISENHAUER,GREG	360616404	00377547	M 64000			137.50

PROJECT EXPENDITURE & BUDGET REPORT

PRINCIPAL INVESTIGATOR K SCHWAN CENTER NO. 246R86870A0 ACCOUNT NO. C-36-X64

TRANSACTIONS FOR MARCH 1996 DEPARTMENT COLL COMP

DATE	DESCRIPTION	DOCUMENT ID/REFERENCE		CODE	BUDGETS	ENCUMBRANCES	EXPENDITURES
TRAVEL							
03/04/96	SCHWAN,KARSTEN	360616403	00375784	M 64000			505.19
03/11/96	EISENHAUER,GREG	360616404		H 64000		438.10	
03/11/96	EISENHAUER,GREG	360616404	00377547	M 64000		-137.50	
03/02/96	SCHWAN,KARSTEN	360616403		H 64000		-1,000.00	
03/02/96	SCHWAN,KARSTEN	360616403		H 64000		790.00	
03/04/96	SCHWAN,KARSTEN	360616403	00375784	M 64000		-505.19	
TOTAL						-414.59	642.69
INDIRECT CHARGES							
TOTAL	RATE OF 46.0%	BASE OF 4				3,202.70	5,608.63
BUDGET CHANGES							
	PERSONAL SERVICES				135,882.00		
	FRINGE BENEFITS				21,425.00		
	MATERIALS AND SUPPLIES				13,063.00		
	TRAVEL				8,080.00		
	SUBCONTRACTS NON-MTDC				25,000.00		
	SUBCONTRACTS MTDC				108,156.00		
	INDIRECT CHARGES				82,050.00		
MONTHLY TOTAL						10,165.10	17,801.30

INDIRECT COMPUTED ON TOTAL DIRECT CHARGES MINUS EQUIPMENT, SUBCONTRACTS OVER AUTHORIZED BASE, AND STUDENT AID

GEORGIA INSTITUTE OF TECHNOLOGY

PRINCIPAL INVESTIGATOR K SCHWAN
CENTER NO. 246R86870A0
ACCOUNT NO. C-36-X64

STATUS AT END OF MARCH 1996
DEPARTMENT COLL COMP

SPONSOR U S DEPT OF DEFENSE

AWARD NUMBER DABT63-95-C-0125
RF CENTER NO. 00641848000
RESTRICTED FUND RF-43824

EFFECTIVE DATE 09-15-95
BILLING GROUP GTRC
EXPIRATION DATE 09-14-96

	MONTH	FISCAL YEAR	TOTAL CONTRACT
PERSONAL SERVICES			
BUDGET			186,674.00
EXPENDED	10,096.65	33,064.11	33,064.11
ENCUMBERED	4,510.32	27,106.95	27,106.95
FREE BALANCE			126,502.94
FRINGE BENEFITS			
BUDGET			29,141.00
EXPENDED	1,033.33	1,147.46	1,147.46
ENCUMBERED	2,866.67	3,100.00	3,100.00
FREE BALANCE			24,893.54
MATERIALS AND SUPPLIES			
BUDGET			18,173.00
EXPENDED	420.00	1,994.75	1,994.75
ENCUMBERED	.00	.00	.00
FREE BALANCE			16,178.25
TRAVEL			
BUDGET			11,360.00
EXPENDED	642.69	1,495.26	1,495.26
ENCUMBERED	-414.59	1,324.41	1,324.41
FREE BALANCE			8,540.33
SUBCONTRACTS NON-MTDC			
BUDGET			25,000.00
EXPENDED	.00	.00	.00
ENCUMBERED	.00	.00	.00
FREE BALANCE			25,000.00

PRINCIPAL INVESTIGATOR	K SCHWAN	CENTER NO. 246R86870A0	ACCOUNT NO. C-36-X64
STATUS AT END OF	MARCH 1996		DEPARTMENT COLL COMP
SPONSOR	U S DEPT OF DEFENSE		
AWARD NUMBER	DABT63-95-C-0125	RF CENTER NO. 00641848000	RESTRICTED FUND RF-43824
EFFECTIVE DATE	09-15-95	BILLING GROUP GTRC	EXPIRATION DATE 09-14-96

	MONTH	FISCAL YEAR	TOTAL CONTRACT	
SUBCONTRACTS MTDC				
BUDGET			161,690.00	
EXPENDED	.00	.00	.00	
ENCUMBERED	.00	.00	.00	
FREE BALANCE			161,690.00	
TOTAL DIRECT CHARGES				
BUDGET			432,038.00	
EXPENDED	12,192.67	37,701.58	37,701.58	
ENCUMBERED	6,962.40	31,531.36	31,531.36	
FREE BALANCE			362,805.06	
INDIRECT CHARGES				
BUDGET			124,323.00	
EXPENDED	5,608.63	17,342.72	17,342.72	RATE OF 46.0 BASE OF 4
ENCUMBERED	3,202.70	14,504.44	14,504.44	
FREE BALANCE			92,475.84	
TOTAL				
BUDGET			556,361.00	
EXPENDED	17,801.30	55,044.30	55,044.30	
ENCUMBERED	10,165.10	46,035.80	46,035.80	
FREE BALANCE			455,280.90	

Object Technology for High Performance Systems

(Final Report for Year 1 - Contract DABT63-95-C-0125)

October 1996

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COBS: Configurable OBjectS for High Performance Systems

1 Introduction

The COBS project is addressing the principles and abstractions of software architectures suitable for seamless operation across complex distributed and parallel platforms. Target platforms will utilize various parallel and sequential machines, multiple network substrates, and they will be subject to dynamic variation in resource availability. Moreover, they will be used by multiple applications with dynamically varying and possibly, conflicting resource demands. The COBS project is investigating the principles and the necessary abstractions that will permit commercially viable software to interact and interoperate across such platforms, such that it can maintain the levels of service desired by end users. Specifically, we posit that any software infrastructure developed toward these ends (1) must be sufficiently general to cover the spectrum of target machines, while (2) it must also permit end users to configure software abstractions (at any time, including during execution) to adapt applications, middleware, and system-level functionality to end user requirements. For generality and due to its commercial relevance, we have chosen the object model of software as a starting point for this work. For reasons of runtime configuration, we have amplified the object model by addition of runtime *attributes* with which objects' implementations may be configured. Using attributes, it is possible to make externally visible the threads-based parallelism internal to objects, thereby enabling efficient parallel implementation across shared memory and distributed machines. Using attributes, it is also possible to configure object implementations at runtime, as well as configure the runtime infrastructure utilized by objects, such as the communication protocols employed for object invocations. Such configuration may employ dynamic resource management algorithms with which desired levels of service are guaranteed, despite variations in underlying platforms or in user behavior. Given the general nature of the object model, it is possible to integrate into object or infrastructure implementations methods for runtime maintenance of desired performance by using techniques like caching, replication, object fragmentation, and adaptation.

2 Design of Configurable Object Architecture

Central notions: CORBA compliance but amplified by mechanisms useful for attaining semantic interoperability of objects, and for composing such objects into what appear to be seamlessly interoperating sets of distributed and parallel services. Our work currently focuses on selected semantic information useful for attaining high performance for such collections of objects.

The key mechanism for capturing object semantics is similar to the one used in real-time objects, called 'attributes'. The COBS attribute infrastructure permits the association of attributes with object classes, instance, and with individual invocations, so that they may be used to configure not just objects but also the infrastructure used by them. The particular 'vertical' configuration (across layers of abstraction capable of interpreting attributes) we are planning to perform is one in which application-level objects configure communication protocol characteristics, including quality of service and security parameters. Additional methods used for dynamic object configuration include caching (object caching at the level of the object system itself), object fragmentation (for objects implementing shared 'memory', as well as for objects implementing event services), and object activity (i.e., the association of events with objects, resulting in active objects). In summary, object and invocation representations may differ significantly even across multiple instances of single object classes, and such representations may be changed at runtime using attributes.

Our current work supports both (1) large-grain, CORBA-compliant objects using the Fresco toolkit (and we are now exploring alternative implementations using SGI's OCS object infrastructure developed as part of their Orlando field trial), and (2) other objects with lower granularities implementing specific kinds of abstractions, including the realization of efficient distributed event services and distributed shared memory, accessible via runtime libraries.

CORBA-compliant language support for COBS objects, for attributes, and for the association of different object representations with classes is provided via IDL and by using 'configuration objects', which may be associated with the objects being configured. Attributes, then, are a basic mechanism useful for 'vertical' configuration, and their use with configuration objects permits end users to easily express desired configuration alternatives, policies, or algorithms. Attributes may also be used as additional parameters carried via invocations with which applications can express desired service levels, negotiate resource access with each other or via more general resource management methods, namely, perform what may be termed 'horizontal' configuration actions.

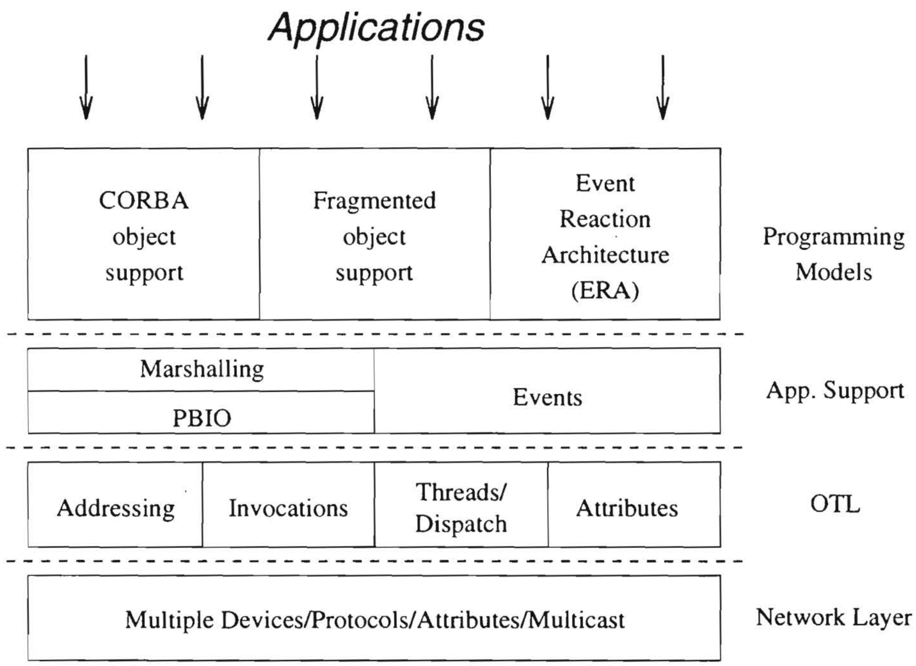

Figure 1: COBS System Architecture

3 Implementation of COBS

The COBS system architecture is summarized in Figure 1 and discussed in more detail below.

3.1 Network Protocols, Communication and Threads

At the lowest level in the architecture figure is a configurable network protocol layer that will allow COBS to customize its operation over several communication protocols, including a real-time protocol offering guarantees for quality of service, a zero copy ATM protocol offering very high performance communications across homogeneous machines, and a configurable communication protocol permitting the on-line reconfiguration and adaptation of selected protocol processing. Conventional protocols will be used as well.

In order to insulate the system from machine differences and provide for efficient heterogeneous operation, a portable binary I/O package (PBIO)[Eis94] is being used in several situations. PBIO is a self-describing data meta-format capable of representing structured information and transmitting it between machines in a reader-makes-right protocol. COBS uses PBIO above the network layer for the transmission information required for its operation. In the past year, PBIO has been extended to support non-connected network communication styles so that it can be used over UDP and similar network protocols.

Above PBIO, a library called DataExchange[ES96a] is used to manage multiple connections, provide server location functionality and to support dynamic connection of new clients.

The Georgia Tech Cthreads library is also used as part of the COBS infrastructure. This library provides user-level threads support on a variety of uniprocessors and shared memory multiprocessors. The instrumentation support in Cthreads allows system and application performance information to be extracted for on-line or post-mortem performance analysis or tuning. This data extraction is done with minimal system perturbation and should prove invaluable in tuning applications and experimenting with new system configurations and protocols.

3.2 The Object Transport Layer

The Object Transport Layer (OTL) is a central component of the system architecture. It is designed to support the operation and inter-operation of a variety of programming models, including: traditional CORBA-style object systems, systems with more complex distributed or fragmented objects, and explicitly reactive object systems like the Event Reaction Architecture. A key feature of the design is the use of object and invocation *attribute lists.*

Attributes are name-value pairs that control system characteristics and provide a uniform mechanism through which the behavior of all layers of the COBS architecture can be configured to achieve the required performance. Among the system characteristics which can be controlled by applications are:

- selecting between multiple object implementations
- creating passive, single-, or multi-threaded objects
- fragmenting or replicating object state
- using reliable, unreliable or multicast protocols for invocations
- specifying compressed or secure protocols for data exchange

Essentially, attributes provide a top-to-bottom configuration mechanism that can be used at all layers of COBS. Attributes are associated with every object operation and so can affect the behavior of any system component involved in performing that operation. Each system component processes the attributes that it understands and the remaining attributes are passed on. When object operations cross machine boundaries, the operation attributes are passed on as well so that the receiving systems behavior can be customized. The range of attributes is not limited or predefined. Because attributes can be examined as well as specified at the application level, they can be used by applications for customizing their own functional behavior as well as for configuring the underlying system.

The OTL is fully functional and supports the configuration of several styles of object invocation and object name specification mechanisms. The configurability of the OTL will be extended as warranted by applications under development.

3.3 Above the OTL

Above the Object Transport Layer are several types of generic services that are useful in object-based applications. user level services:

DSM Services – Distributed shared memories (DSM) allow processes to share memory objects even when they execute in environments such as workstation cluster where shared memory is not provided by the the hardware. We have implemented Indigo, a user-level library which can be used to implement several types of distributed memory systems. We have already implemented a DSM that exploits weak consistency and synchronization information to provide high performance memory objects.

Caching and Consistency Services – We have implemented causal consistency and strong consistency object caching mechanisms using the mutual consistency mechanism[KA96]. We also implemented a DASH style consistency protocol that is used in the XFS file system in order to quantify the advantages of our strong consistency protocol over traditional protocols.

The prototype has also been ported to use the Object Transport Layer as the transport instead of Fresco's native reliable request-response protocol transport. The port exploited the subcontract mechanism that Fresco's Object Communication System (OCS) uses. This will allow the object caching system to take advantage of the features in OTL. For example, while the object caching system currently allows only class implementors to specify whether or not caching should be used (and the desired level of consistency), attributes can be easily employed to allow client applications to indicate application specific requirements to the caching system.

In a separate, but related, effort as described in [WSTA], we have implemented a system that attempts to exploit spatial and temporal locality in object references in order to reduce overall locking overheads. This system will be ported to OTL in the next few months.

Object Event Services – Events have been receiving renewed attention in the OS community as a useful structuring mechanism for distributed and parallel systems. Event services also form the basis of the Event Reaction Architecture that IBM is developing as their structuring tool for collaboration environments. Given this interest we are developing a configurable user-level event services library. The DataExchange and PBIO libraries already provide us with significant infrastructure in this effort. Our next efforts will be to add object-specific delivery and routing mechanisms and to provide an efficient implementation of the CORBA Event Services specification for use by COBS programs.

Applications – A variety of applications on top of OTL and its associated services are planned or in the works. Some of these applications are useful because they drive the development of specific features and configurability in lower layers. Others are of interest because of the novel elements that object-level configurability enables at the application level. In the former category, we have complex applications in the area of atmospheric modeling and molecular dynamics which can take advantage of configurability in their network interactions to improve performance. Encapsulating the network interfaces of those applications in object-based interfaces also allows us to introduce complex optimizations without complicating the structure of the application. A joint Georgia Tech/Honeywell project also shows promise of improving programability and functionality through application-level configurability. This project seeks to facilitate efficient use of processing and communication resources through dynamic relocation of an applications functional components.

4 Evaluation and Experimentation with COBS

The first year of the COBS project was largely spent creating the basic object system and infrastructure. Many efforts now are directed towards evaluating and refining the use of COBS's configuation mechanisms and techniques. The understanding gained from the process will be used to judge the suitability and flexibility of the COBS mechanisms as well as to evaluate the types of configurability that can be exploited at various levels of the COBS system. In particular, the following efforts are in progres:

- Performance evaluation of the object caching prototype is under way. We have implemented a sophisticated synthetic workload generator based on large scale distributed file system traces from Princeton University and traces from a wide area industrial file system. The workload generator takes into account factors such as file inertia, file entropy, temporal locality, read-write sharing within and among clusters. Initial results of the evaluation corroborate our hypothesis. This is an example of horizontal use of configuration attributes. That is, use of characteristics on one side of an exchange being used to configure the behavior of a similar level on the opposite side of an exchange.
- We are also proceeding with a variety of vertical configuration experiments, in which lower levels benefit from application-level information. One example of the use of application-level information is in a fast ATM protocol we are developing. In situations where buffer requirements can be predicted, this protocol implements a zero-copy ATM receive operation by depositing incoming messages directly into user address space.
- Other vertical configuration efforts include the ability to select from a variety of network transport mechanisms for different object invocations, to adjust and specify protocol-level quality of service requirements, use of application-level information to control encryption/decryption or compression/uncompression, and configurability for dynamic communications resource management in order to maximize throughput.

5 Next Steps

As the basic elements of COBS are in place, the next steps in the COBS project involved extending the range of configuration options, experimenting with combinations of configuration at different layers in the COBS system and continuing our work with sample applications. Among the planned projects are:

dynamic resource management – The COBS configuration facility allows the application to make significant information available to the run-time system. We intend to explore mechanisms for using this information to make scheduling and resource management decisions for both computing and communication resources.

vertical configuration – Application information can also be used to perform top-to-bottom configuration of the protocol stack in order to derive and provide quality of service requirements, select amongst available network interfaces, and enable security and compression techniques.

scientific applications – Work continues on a variety of applications which hope to exploit the COBS system. Among these are scientific applications such as molecular dynamics [ES96b] and global climate modeling [KSS+96] which can benefit from improved perfomance. The use of COBS will also be explored in a variety of collaborative and interactive situations, including display processing and interactive steering for the scientific applications.

COTS applications – Together with a commercial vendor we are exploring the application of COBS to a distributed work-flow management system. The utilization of COBS in this domain would enable the creation of seamlessly integrated and easily managed distributed systems and applications. We are also continuing work with IBM to develop event-based collaborative work environments.

DoD applications – A joint Georgia Tech/Honeywell project also shows promise of improving programability and functionality through application-level configurability. This project seeks to facilitate efficient use of processing and communication resources through dynamic relocation of an applications functional components.

6 Contribution of COBS to DARPA Mission

In summary, the Configureable OBject Systems projects contributes to the DARPA mission by providing:

- Techniques for seamless object services on high performance platforms
- System configuration for changes in missions and platforms
- A platform which is usable with COTS and DoD applications and platforms

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